भारतीय मानक
Indian Standard

IS 15490 : 2017
(Reaffirmed 2022)

स्वचल वाहनों के लिए ईंधन के रूप में संपीड़ित प्राकृतिक गैस के ऑन-बोर्ड भंडारण के लिए जोड़ रहित स्टील सिलेंडर — विशिष्टि

(पहला पुनरीक्षण)

Seamless Steel Cylinders for on-Board Storage of Compressed Natural Gas as a Fuel for Automotive Vehicles — Specification

(Reaffirmed 2022)

(First Revision)

ICS 23.020; 43.040

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Gas Cylinders Sectional Committee, MED 16

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Gas Cylinders Sectional Committee had been approved by the Mechanical Engineering Divisional Council.

This standard was first published in 2004. In this revision all the amendments have been incorporated and efforts have been made to align with ISO 9809-1 : 2010 ‘Gas cylinder — Refillable seamless steel gas cylinders — Design, construction and testing — Part 1: Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa’. However, considering the prevailing practices of cylinder manufacturing in the country, necessary additions are made wherever necessary.

Assistance has also been taken from:

> ISO 11439 : 2013 Gas cylinder — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles
>
> ISO 13769 : 2002 Gas cylinders — Stamp-marking

Clause **3.2.3.1** of this standard has been derived mainly from IS 15958 : 2012 ‘Compressed natural gas (CNG) for automotive purpose — Specification’. The purpose of this standard is to provide a specification for the design, manufacture, inspection and testing of a high pressure cylinder for worldwide usage. The objective is to balance design and economic efficiency against international acceptance and universal utility.

Periodic inspection and testing of high pressure gas cylinders is covered in IS 8541 : 2009 ‘Periodic inspection and testing of high pressure gas cylinders — Code of practice’.

While implementing this standard, the manufacturer and the inspection agency shall ensure compliance with statutory regulations. It is the responsibility of the owners and the users to ensure that the cylinders are periodically tested as per norms laid down in *Gas Cylinder Rules,* 2004 as amended from time-to-time and as enforced by statutory authorities under the rules.

The relevant SI units and corresponding conversion factors are given below for guidance:

Pressure 1Pa (Pascal) = 1 N/m^2
1 kgf/mm^2 = 9.806 65 MPa

The composition of the Committee responsible for the formulation of this standard is given in Annex G.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SEAMLESS STEEL CYLINDERS FOR ON-BOARD STORAGE OF COMPRESSED NATURAL GAS AS A FUEL FOR AUTOMOTIVE VEHICLES — SPECIFICATION

(First Revision)

1 SCOPE

This standard deals with seamless steel cylinders of water capacity not exceeding 250 litre intended only for on-board storage of compressed natural gas as a fuel, intended to be permanently fixed to the automotive vehicle. This standard lays down the minimum requirements of the material, design, construction, marking and testing.

Maximum working pressure of compressed natural gas (CNG) cylinder on-board should correspond to the maximum filling pressure at 15°C, that is 20 MPa (200 bar/204 kgf/cm^2).

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

IS No.	*Title*
1500 : 2005	Method for brinell hardness test for metallic materials (*third revision*)
1586 : 2000	Method for Rockwell hardness test for metallic materials (Scales A-B-C-D-E-F-G-H-K 15N, 30N, 45N; 15T, 30T and 45T) (*third revision*)
1608 : 2005	Mechanical testing of metals tensile testing (*second revision*)
1757 : 1988	Method for Charpy impact test (V-notch) for metallic materials (*second revision*)
3224 : 2016	Valve fittings for compressed gas cylinders excluding liquefied petroleum gas LPG) cylinders — Specification (*fourth revision*)
3745 : 2006	Identification of the contents of industrial gas cylinders (*first revision*)
4379 : 1981	Identification of the contents of industrial gas cylinders (*first revision*)
5844 : 2014	Recommendations for hydrostatic stretch testing of compressed gas cylinders (*first revision*)
7241 : 1981	Glossary of terms used in gas cylinder technology (*first revision*)
15126 : 2002	Natural gas — Standard reference conditions

3 TERMINOLOGY

For the purpose of this standard, in addition to the definitions given in IS 7241, the following definitions shall apply:

3.1 Gas Cylinder — Any closed metal container having a volume exceeding 0.5 litre but not exceeding 1 000 litre intended for the storage and transport of compressed gas, including compressed natural gas container fitted to a motor vehicle as its fuel tank, but not including any other such containers fitted to a special transport or under carriage.

3.2 Service Conditions

3.2.1 *Service Life* — The service life for which cylinders are safe shall be specified by the cylinder manufacturer on the basis of use under service conditions specified herein. The maximum service life shall be 20 years.

The ultrasonic inspection, or equivalent, of each cylinder shall ensure the absence of flaws which exceed the maximum allowable size. This approach permits the optimized design and manufacture of light weight cylinders for natural gas vehicle service. The service life shall be demonstrated by appropriate design methods, design qualification testing and manufacturing controls.

3.2.2 *Maximum Pressure* — This standard is based upon a working pressure of 20 MPa (200 bar) settled at 15°C for natural gas as a fuel with a maximum filling pressure of 26 MPa (260 bar) regardless of filling condition or temperature.

3.2.3 *Gas Composition*

3.2.3.1 *General* — Methanol and/or glycol shall not be deliberately added to the natural gas. Cylinders shall be designed to tolerate being filled with natural gas meeting the specifications of gas as follows:

Sl No. (1)	*Characteristic* (2)	*Requirement* (3)
i)	Water content[1)], mg/m^3, *Max*	5.0
ii)	Hydrocarbons (volume percent of total organic carbon present)	
	a) Methane, *Min*	90.0
	b) Ethane, *Max*	6.0
	c) C_3 and higher HC, *Max*	3.0
	d) C_6 and higher HC, *Max*	0.5
	e) Total unsaturated HC, *Max*	0.5
iii)	Corrosive components	
	a) Total sulphur[2)] mg/m^3, *Max*	20.0
	b) Oxygen volume percent, *Max*	0.5
iv)	Carbon dioxide and nitrogen volume percent, *Max*	3.5
v)	Other species (mole percent)	0.1
	a) Hydrogen, *Max*	
	b) Carbon monoxide, *Max*	0.1
vi)	Methane number, *Min*	90.0

NOTE — The requirement of oil content shall be added at a later stage when test method for the same is available.

[1)] Requirements are according to IS 15126.

[2)] Total sulphur includes the sulphur content of odorant.

3.3 Temperature Range

3.3.1 *Gas Temperature* — Cylinder shall be designed to be suitable for the following gas temperature limits:

a) The settled temperature of gas in cylinders, which may vary from a low of –20 °C to a high of +65 °C; and

b) The developed gas temperature during filling, storage and discharge which vary beyond these limits. However, this should not exceed + 75 °C.

3.3.2 *Cylinder Temperatures* — Cylinder shall be designed to be suitable for the following gas temperature limits:

a) Temperature of the cylinder material which may vary from -20°C to +82°C, and

b) Temperature over 65°C shall be sufficiently local, or of short enough duration, that the temperature of the cylinder never exceeds 65 °C, except under the condition **3.3.1** (b).

3.4 Normalizing — Heat treatment in which a cylinder is heated to a uniform temperature above the upper critical point (AC3) of the steel and then cooled in still air.

3.5 Quenching — Hardening heat treatment in which a cylinder, which has been heated to a uniform temperature above the upper critical point AC3, of the steel, is cooled rapidly in a suitable medium.

3.6 Tempering — Softening heat treatment which follows Quenching or Normalizing , in which the cylinder is heated to a uniform temperature below the lower critical point, AC1, of the steel, then cooled in still air.

3.7 Yield Stress (R_e) — Value corresponding to the upper yield stress, R_{eH} or, for steels that do not exhibit a defined yield, the 0.2 percent proof stress (non-proportional elongation), $R_{P0.2}$.

3.8 Batch — Quantity of up to 200 cylinders plus cylinders for destructive testing of the same nominal diameter, thickness and design, made successively from the same steel and same heat and subjected to the same heat treatment for the same duration of time.

3.9 Working Pressure (P_w)/ Service Pressure — Working pressure means the internal pressure of the gas in the cylinders at a temperature of I5°C.

3.10 Test Pressure (P_h) — Test pressure means the internal pressure required for the hydrostatic stretch test of the cylinders.

NOTE — It is used for cylinder wall thickness calculation.

3.11 Burst Pressure (P_b) — Highest pressure reached in a cylinder during burst test.

4 SYMBOLS

a = calculated minimum thickness, in mm, of the cylindrical shell;
á = guaranteed minimum thickness, in mm, of the cylindrical shell (*see* Fig. 1);
A = percentage elongation on gauge length $5.65\times\sqrt{S_o}$;
b = guaranteed minimum thickness, in mm at the centre of a convex base (*see* Fig. 1);
D_o = nominal outside diameter of the cylinder, in mm (*see* Fig. 1);
D_i = nominal inside diameter of the cylinder, in mm;
D_F = diameter, in mm of former (*see* Fig. 6);

H = outside height, in mm, of domed part (convex head or base end) (*see* Fig. 1);

l = length of cylindrical part of the cylinder, in mm (*see* Fig. 4);

L_o = original gauge length, in mm;

n = ratio of the diameter of the bend test former to actual thickness of test piece (t);

P_b = measured burst pressure in bar or kgf/cm^2;

P_h = hydraulic test pressure, in bar or kgf/cm^2, above atmospheric pressure;

P_w = working pressure/service pressure in bar or kgf/cm^2, above atmospheric pressure;

r = inside knuckle radius, in mm (*see* Fig. 1);

R_e = minimum guaranteed value of yield stress (*see* **3.7**), in MPa or kgf/mm^2;

R_{eH} = value corresponding to the upper yield stress;

R_g = minimum guaranteed value of tensile strength, in MPa or kgf/mm^2;

R_m = actual value of tensile strength in MPa or kgf/mm^2; as determined by the tensile test (*see* **9.3.1**);

S_o = original cross-sectional area of tensile test piece, in mm^2 according to IS 1608; and

t_e = actual thickness of the test specimen, in mm.

5 MATERIALS

5.1 General Requirements

5.1.1 The steel used shall be such that its properties meet the requirements of the finished product. The steel shall be aluminium or silicon killed with non-aging properties, other than rimming qualities. The chemical composition of all steels shall be declared and defined at least by:

a) Carbon, manganese and silicon content in all, and

b) The chromium, nickel, molybdenum, vanadium and that of any other alloying elements intentionally added to the steel.

NOTES

1. In case the steel is chromium with nickel, its value shall be nickel 2.30 – 2.80, molybdenum 0.40 – 0.70 and chromium 0.50 – 0.80.

2. When aluminium or a combination of aluminium and silicon is used for killing. The steel, the requirements regarding minimum silicon content does not apply.

3. When steel is aluminium and silicon killed, nitrogen content shall be limited to 0.01 percent.

4. When steel is aluminium killed by aluminium alone, nitrogen content is limited to 0.007 percent.

5.1.2 The cylinder manufacturer shall establish means to identify the cylinders with the cast of steel from which they are made.

5.2 Controls on Chemical Composition

5.2.1 The chemical composition of all steels shall be defined at least by:

a) Carbon, manganese and silicon contents in all cases;

b) Chromium, nickel and molybdenum contents or other alloying elements intentionally added to the steel; and

c) Maximum sulphur and phosphorus contents in all cases.

The carbon, manganese and silicon contents and, where appropriate, the chromium, nickel and molybdenum contents shall be given, with tolerances, such that the differences between the maximum and minimum values of the cast do not exceed the values shown in col 5 of Table 1.

The combined content of the elements like vanadium, niobium, titanium, boron and zirconium, shall not exceed 0.15 percent.

5.2.2 Sulphur and phosphorus in the cast analysis of material used for the manufacture of gas cylinders shall not exceed the values shown in Table 2.

Table 1 Chemical Composition Tolerances

(*Clauses* 5.2.1 *and* 5.3)

Sl No.	Element	Maximum Content in Percentage	Maximum Deviations in Percentage	Maximum Range in Percentage
(1)	(2)	(3)	(4)	(5)
i)	Carbon	< 0.30	0.06	0.06
		≥ 0.30	0.07	0.07
ii)	Manganese	All values	0.30	0.30
iii)	Silicon	All values	0.30	0.30
iv)	Chromium	< 1.50	0.30	0.30
		≥ 1.50	0.50	0.50
v)	Nickel	All values	0.40	0.40
vi)	Molybdenum	All values	0.15	0.15

Table 2 Maximum Sulphur and Phosphorus Limit in Percentage

(*Clause* 5.2.2)

Sl No.	Element	Maximum Content Limit in Percentage	
		for R_g < 950 MPa	for $R_g \geq$ 950 MPa
(1)	(2)	(3)	(4)
i)	Sulphur	0.020	0.010
ii)	Phosphorus	0.020	0.020
iii)	Sulphur and phosphorus	0.030	0.025

5.3 The cylinder manufacturer shall obtain and provide certificates of cast (heat) analysis of the steels supplied for the construction of gas cylinders.

If check analyses be required, they shall be carried out either on specimens taken during manufacture from the material in the form as supplied by the steelmaker to the cylinder manufacturer, or from finished cylinders.

In any check analysis, the maximum permissible deviation from the values specified for the cast analyses shall conform to the values specified in col 4 of Table 1.

5.4 Typical Steels

Two typical nationally/internationally recognized steel types which have provided safe performance over many years are:

a) Chromium molybdenum steel (quenched and tempered); and
b) Carbon manganese steel (quenched and tempered).

The chemical compositions of these steels, subject to the controls specified in **5.2** are given in Table 3.

Table 3 Internationally Recognized Steel Composition (Cast Analyses)

(*Clause* 5.4)

Sl No.	Element	Steel Grade and Conditions (In Percentage)	
		Cr-Mo (Q&T)	C-Mn (Q&T)
(1)	(2)	(3)	(4)
i)	Carbon	0.25-0.38	0.38, *Max*
ii)	Silicon	0.10-0.40	0.10-0.35
iii)	Manganese	0.40-1.0	1.35-1.70
iv)	Phosphorus	0.02, *Max*	0.02, *Max*
v)	Sulphur	0.02, *Max*	0.02, *Max*
vi)	Chromium	0.8-1.2	—
vii)	Molybdenum	0.15-0.40	—

5.5 Suitable steels other than above may be used with the prior permission of the statutory authority. In such a case, the yield strength of the steel taken for the purpose of calculating the wall thickness of the cylinder shall not be greater than the minimum specified value.

5.6 Heat Treatment

The actual temperature to which a type of steel is subjected for a given tensile strength shall not deviate by more than 30°C from the temperature specified by the cylinder manufacturer.

After end forming, the cylinders shall be heat treated (quenched and tempered) to the hardness range as specified in the cylinder approved drawing.

During heat treatment the following temperatures shall be maintained:

Heat Treatment	*Material*	
	Cr-Mo	C-Mn
Hardened	820 °C, *Min*	820 °C, *Min*
Tempered	550 °C, *Min*	540 °C, *Min*

The cylinder manufacturer shall certify the heat treatment process applied to finished cylinder. It shall conform the requirement given at **10.1**.

6 DESIGN

6.1 General Requirements

6.1.1 The calculation of the wall thickness of the parallel wall of cylinder shall be based on the guaranteed minimum yield stress (R_e) of the material.

6.1.2 For calculation purposes, the value of $\underline{R}_e$ shall not exceed 0.85 R_g.

6.1.3 The internal pressure upon which the calculation of wall thickness is based shall be the hydraulic test pressure (P_h).

6.2 Limitation on Tensile Strength and Hardness

Maximum tensile strength shall be limited to 1 100 MPa and hardness shall not exceed 330 BHN. In case upper limit of tensile strength exceeds 950 MPa steel shall be subjected to sulphide stress cracking resistance test as given in **9.3.4**.

6.2.1 *Calculation of Cylindrical Shell Thickness*

6.2.1.1 The minimum wall thickness of the cylindrical shell of the cylinder to be calculated by following formulae:

$$f = \frac{P_h \times (1.3\,D_o^2 + 0.4\,D_i^2)}{100 \times (D_o^2 - D_i^2)}$$

$$a \qquad \frac{D_o}{250} + 1$$

with absolute minimum of $a = 1.5$ mm

where

f = maximum allowable wall stress at hydrostatic test pressure, in kgf/mm^2;
= 5/6 R_e, R_e being the minimum value of the yield strength in kgf/mm^2; and

P_h = hydrostatic test pressure above atmospheric, in kgf/cm^2 (5/3 × working pressure).

6.2.2 The value of the wall thickness as calculated from above formula shall however, be not less than 0.136 .

6.3 Calculation of Convex Ends (Heads and Bases)

6.3.1 When convex ends (heads as well as bottoms) are formed by forging of cylindrical parts (*see* Fig. 1) the wall thickness in the centre of the formed end shall, provided that the inside corner radius r is not less than 0.075 D_o, be at least 1.5 a' if the outside height of the domed part is greater than 0.25 D_o, and at least 2 a' if the outside height of the domed part is less than 0.25 D_o but not less than 0.2 D_o and a' being the guaranteed minimum wall thickness of the cylindrical shell.

$\sqrt{D_o}$

6.3.1.1 For cylinders manufactured from plate, the thickness, b, at the centre of a convex end shall be not less than that required by the following criteria:

$b \quad 1.5a'$ *for* $0.40 > H/D_o \quad 0.20$

$b \quad a'$ *for* $H/D_o \quad 0.40$

where the inside knuckle radius, r is not less than 0.075 D_o.

6.3.1.2 In order to obtain a satisfactory stress distribution in the region where the end joins the shell any thickening of the end that is required shall be gradual from the point of juncture, particularly at the base. For the application of this rule the point of juncture between the shell and the end is defined by the horizontal line indicating dimension H in Fig. 1.

6.3.2 Nevertheless, if the shape of the convex end is such that the following conditions are fulfilled

$R \quad D_o$

$r \quad 0.1\,D_o$

where

R = inside dishing radius, in mm; and
r = inside knuckle radius, in mm (*see* Fig. 1).

The wall thickness of the end will be acceptable, if it is nowhere less than the value t_e, when calculated with the following formula:

$$t_e = a \times F$$

where F is a shape factor, the value of which depends on the value of H/D_o and if $H/\,D_o \quad 0.25$, also on t_e/D_o, H is the outside height of the domed part of the convex end.

For wall thickness up to and including 5 mm, the value of F shall be obtained from Fig. 2 and Fig. 3.

6.4 The outside height H mentioned at **6.2.2** is the distance from the plane of the cross-section at the extreme limit of the cylindrical part of the cylinder to the farthest point of the centre of the connecting formed end. For the application of this rule:

a) The cylindrical part of the cylinder includes any portion with slight deviations of the geometrical cylindrical shape, such as more or less conical wall inside or outside or at both surfaces, reduction in diameter for a foot ring, etc; and

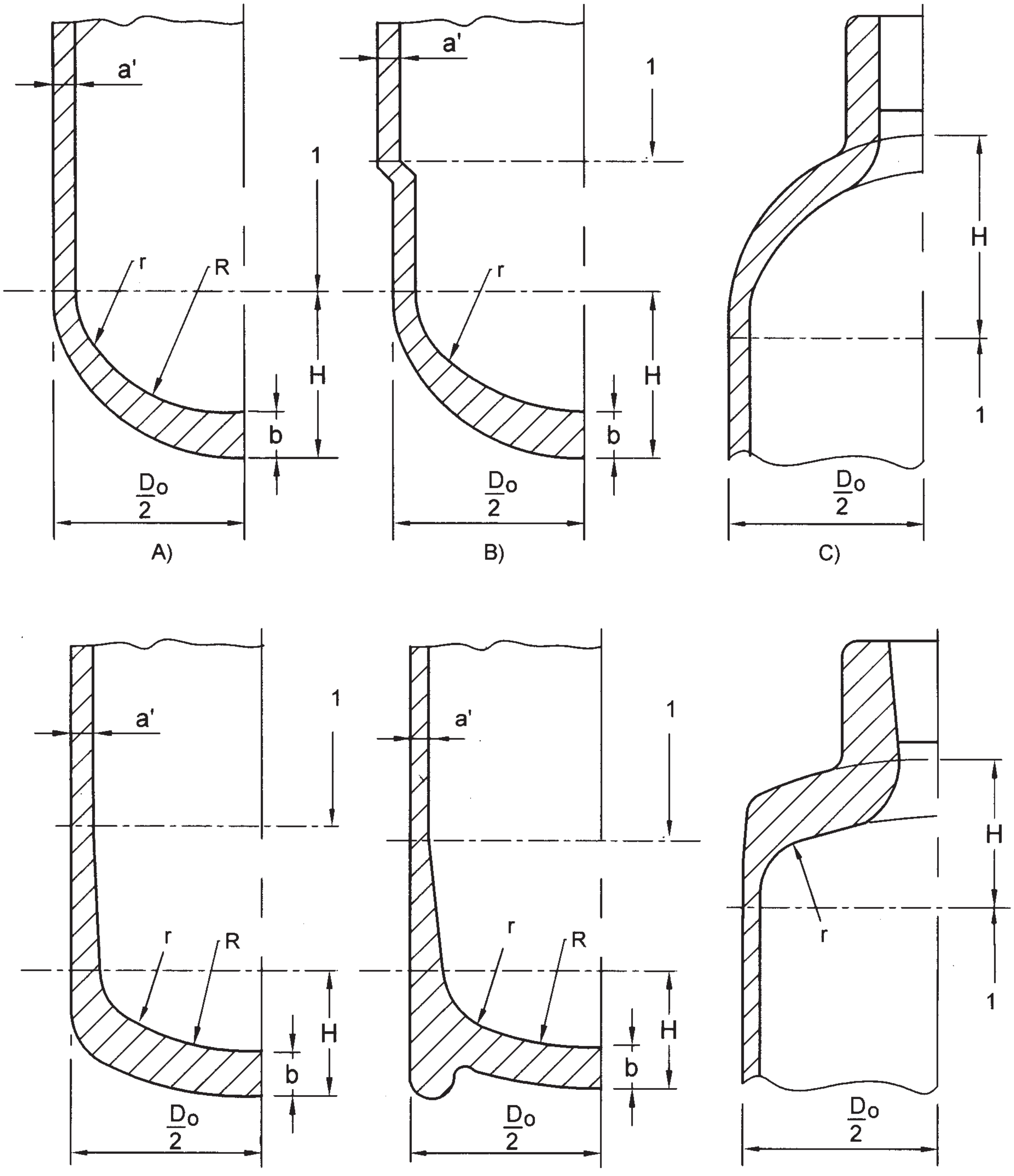
b) The top of the cylinder bearing the valve shall be considered without extrusion and without hole in the centre (*see* Fig. 1).

6.4.1 The cylinder manufacturer shall in any case prove by pressure cycling test as given in **8.2.3** that the design is satisfactory.

6.5 Neck Design

6.5.1 The external diameter and thickness of the neck end of the cylinder shall be adequate for the torque applied in fitting the valve to the cylinder. The torque may vary according to the diameter of thread, the form of thread and the sealant used in the fitting of the valve (for guidance on torque, *see* IS 3224 and IS 3745).

6.5.2 In establishing the minimum thickness, consideration shall be given to obtain a thickness of wall in the cylinder neck which will prevent permanent expansion of the neck during the initial and subsequent fittings of the valve into the cylinder without support of an attachment such as a neck ring. Where the cylinder is specifically designed to be fitted with such reinforcement, such as neck ring,



Key
1 — Cylindrical part
NOTE — Shape B shall not be excluded from this requirement.

FIG. 1 TYPICAL CONVEX ENDS

or shrunk-on collar, the same shall be taken into account.

6.5.3 *Valve Fittings*

The cylinder neck shall be threaded to suit the type of valves as given in IS 3224 or any other specification as approved by the statutory authority. The threads shall be full form, clean cut even and without chatter, answering to gauges, and concentric with the axis of the cylinder.

6.6 Design Drawing

6.6.1 A fully dimensioned drawing shall be prepared which includes the specification of the material (cast

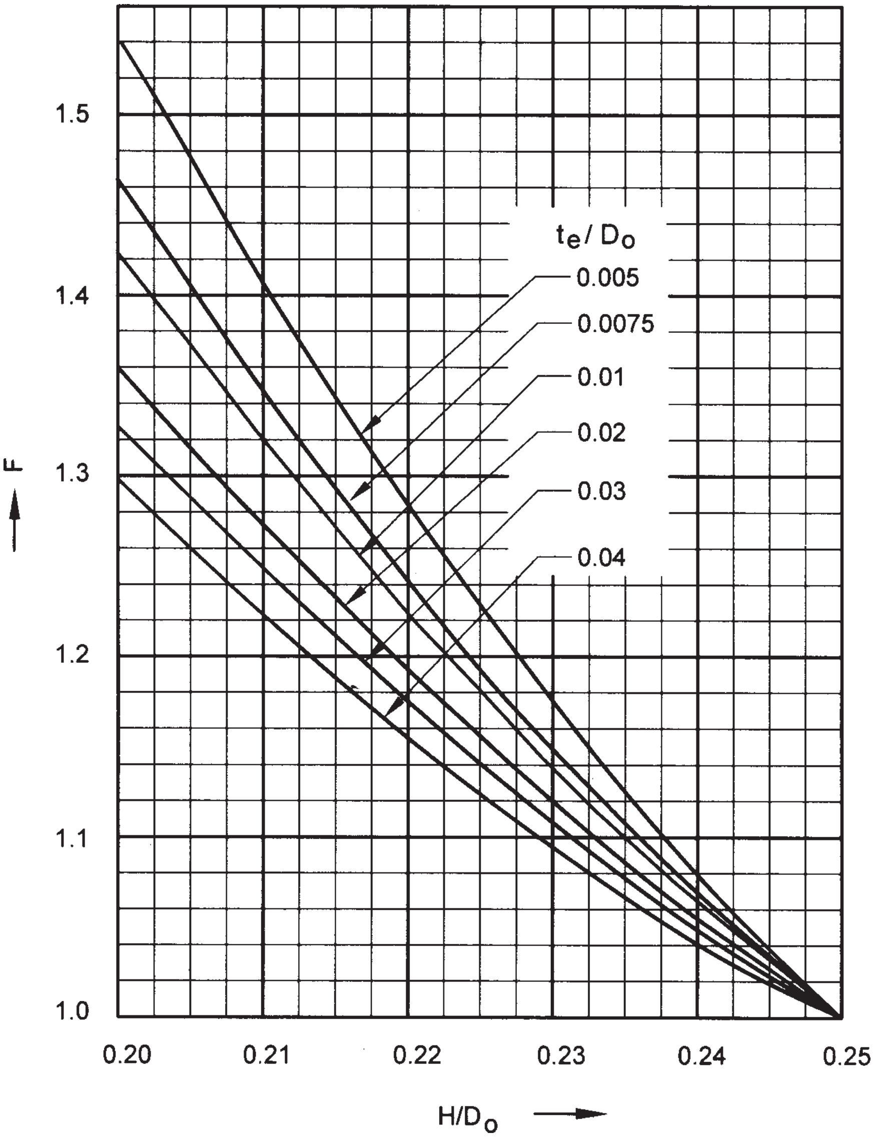


FIG. 2 VALUES OF SHAPE FACTOR F FOR H/D_o BETWEEN 0.20 AND 0.25

analyses), neck threads, mechanical properties selected for calculating the wall thickness, heat treatment parameters, hardness range, working pressure, test pressure, water capacity, length and weight.

7 MANUFACTURE

The cylinder shall be produced by any one of the following methods:

a) forging or drop forging from a solid ingot or billet;
b) manufacturing from seamless tube (hot/cold finish, flow formed);
c) pressing from a flat plate;
d) closing of the open ends may be done by any hot working processes such as spinning, forging, etc; and
e) Cylinders may be designed with one or two openings along the central cylinder axis. Metal shall not be added in the process of closure of the end. Plugging to correct manufacturing defects in cylinder bases is not permitted.

7.1 Examination of Cylinders before Closing in Operation

Each cylinder shall be examined before final closing in operation for thickness and surface defects.

7.2 Cylinder Shape and Wall Thickness

The cylinder design shape and wall thickness shall be such that the requirements for performance are complied with and the dimensions of all cylinders fall within the tolerances shown on the approved design drawing.

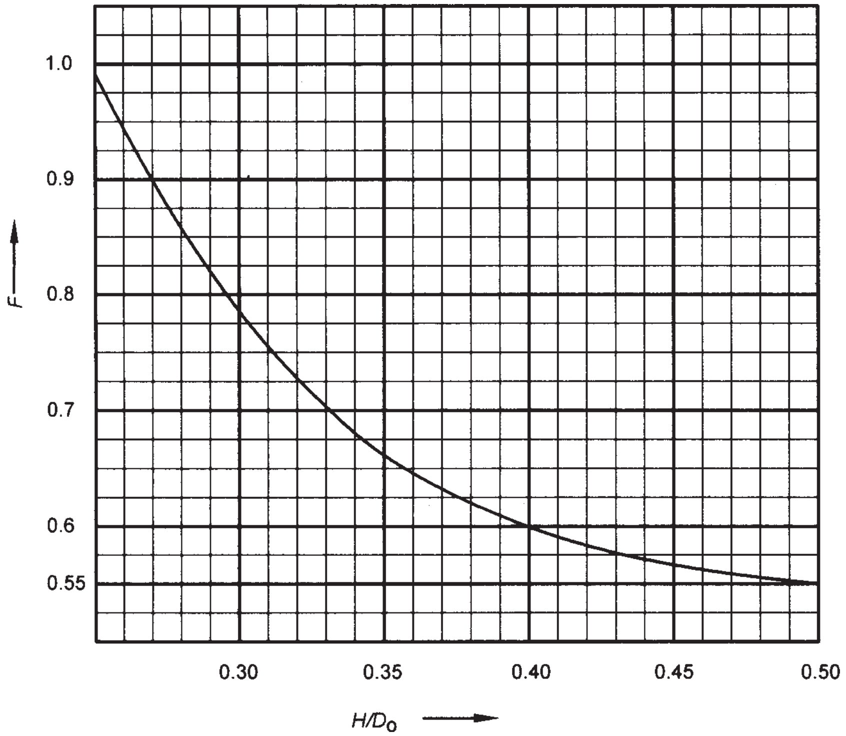


FIG. 3 VALUES OF SHAPE FACTOR F AND H/D_o BETWEEN 0.25 AND 0.50

7.3 Surface Defect

The internal and external surfaces of the finished cylinder shall be free from defects which would adversely affect the safe working of the cylinder. *See* Annex A for examples of defects and guidance on their evaluation.

7.4 Ultrasonic Examination

Each cylinder shall be ultrasonically examined for defects in accordance with Annex B.

7.5 Cylinder Neck Threads and Fittings

7.5.1 The cylinder shall have threads as per IS 3224 or any other threads specification approved by statutory authority. Threads shall be full form, clean cut, even and without crack, machined to gauge and concentric with axis of cylinder.

7.5.2 The cylinder valve, if fitted shall be tightened to required torque using suitable tape or by suitable sealant.

7.6 Out-of-Roundness

The out-of-roundness of the cylindrical shell that is the difference between the maximum and minimum outside diameters at the same cross-section shall not exceed 2 percent of the mean of these diameters.

7.7 Mean Diameter

The mean external diameter of the cylindrical part outside the transition zones on a cross-section shall not deviate more than ±1 percent from the nominal design diameter.

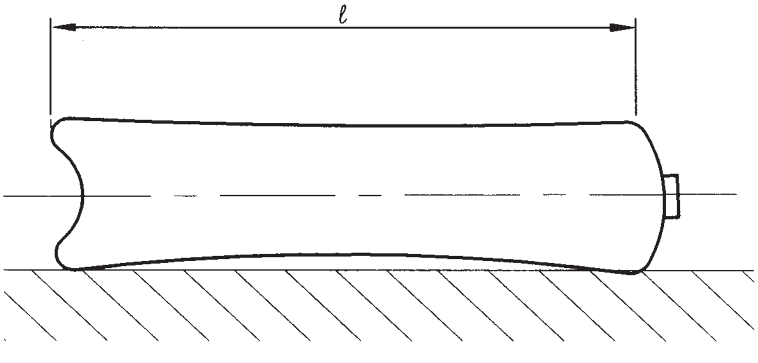


FIG. 4 CYLINDER STRAIGHTNESS

7.8 Straightness

The maximum deviation of the cylindrical part of the shell from a straight line shall not exceed 3 mm/m length (*see* Fig. 4).

7.9 Testing Requirements

The material of the finished cylinder shall satisfy the requirements given in **9** (Type Approval Procedure), **10** (Batch Test) and **11** (Test on Every Cylinder).

7.10 Re-tests

In the event of failure to meet the test requirement in hardness testing individual cylinder shall be hardened and tempered to meet the specific requirement. It shall continue to be part of original batch unless the repeat heat treatment temperature differs by more than 30 °C from the first heat treatment.

In case of failure in carrying out the batch testing as per **9** following re-testing procedures shall be followed.

7.10.1 If the sample fails in any of the test specified in **9.3.1, 9.3.2** and **9.3.3** and if the inspecting authority considered that failure was due to an error in carrying out the test, a fresh test shall be made on a test piece taken from the same cylinder. The defective test shall be ignored but otherwise, at the cylinder maker discretion, one of the following procedures shall be adopted:

a) The test in which the failure occurred shall be repeated on the cylinder or test ring originally tested and, in addition, the test specified in **9.3.1, 9.3.2** and **9.3.3** shall be carried out on another cylinder or test rings from the same batch of the cylinders. If both test rings comply with the test requirements of **9.3.1, 9.3.2** and **9.3.3** the batch may be accepted.

b) The batch may be reheat-treated as given in **5.6** and the tests specified in **9.3.1**, **9.3.2** and **9.3.3** shall be carried out on two cylinders or test rings at the discretion of inspecting authority, which have not been previously tested. If both the cylinders or test rings satisfy the test requirements, the batch may be accepted.

7.10.2 If any of the tests specified in **9.3.1**, **9.3.2** and **9.3.3** fail, the batch may be reheat-treated as given in **5.6** and retested as given in **7.10.1** (b). If both cylinders or test rings satisfy the test requirements, the batch may be accepted.

7.10.3 No cylinder shall, however, be reheat-treated more than three times. Also, if more than five cylinders in a batch are reheat-treated, they shall constitute a new batch as given in **9.3.1**, **9.3.2** and **9.3.3**.

7.10.4 Not more than five cylinders or test rings from batch shall be submitted to the test and the limitations on reheat-treatment given in **7.10.3** shall be complied with.

7.10.5 If after the permitted number of re-tests and reheat-treatments the tests requirements have not been complied with, the cylinders in the batch shall be rendered unserviceable for holding the gas under pressure.

7.10.6 If any cylinder fail to meet the requirements of hydrostatic stretch test in terms of stretch, or burst test, no further cylinder conforming to that drawing, shall be accepted from the manufacturer until it has been demonstrated to the satisfaction of the inspector that the cause of the failure has been identified and corrected. Also, for the batch under consideration, each of the remaining cylinder should be demonstrated to the satisfaction of the inspector, to be free from the defect which caused the failure.

NOTE — If manufacturer convince that failure in burst test is due to heat treatment and if inspection authority convince about the reason, the permission may be given by statutory authority in consultation with inspecting agency.

8 INSPECTION AND TESTING

In order to ensure that the cylinders are in compliance with this standard, they shall be subject to inspection and testing in accordance with **9** (Type Approval Procedure), **10** (Batch Tests) and **11** (Test on Every Cylinder) by an authorized inspection body (hereafter referred to as 'the inspector') recognized by the statutory authority.

9 TYPE APPROVAL PROCEDURE

9.1 General Requirement

A technical specification of each new design of cylinder [or cylinder family as defined in (f)] including design drawing, design calculations, steel details and heat treatment, shall be submitted by the manufacturer to the statutory authority, through the inspection agency. The test detailed in **9.2** shall be carried out on each new design under the supervision of the inspector.

A cylinder shall be considered to be a new design, compared with an existing approved design, when:

a) it is manufactured in a different factory; or
b) it is manufactured by a different process; or
c) it is manufactured from a steel of different specified chemical composition or manufacturer of the material changes; or
d) it is given a different heat treatment beyond the stipulated limit; or
e) ends or ends profile has changed for example convex, hemispherical, torispherical, ellipsoidal or also if there is a change in base thickness cylinder diameter ratio; or
f) overall length of the cylinder has changed more than 50 percent (cylinders with a length-diameter ratio less than three shall not be used as reference cylinders for any new design with this ratio greater than three); or
g) nominal outside diameter has changed more than 5 percent; or
h) hydraulic test pressure has been increased (where a cylinder is to be used for lower pressure duty than that for which design approval has been given, it shall not be deemed to be a new design); or
j) guaranteed minimum yield stress (r_e) and/or the guaranteed minimum tensile strength (r_g) have changed; or
k) design wall thickness has changed.

9.2 Prototype Tests

9.2.1 A minimum of 50 cylinders which are guaranteed by the manufacturer to be representative of the new design shall be made available for prototype testing. However, if for special applications the total number of cylinders required is less than 50, enough cylinders shall be made to complete the prototype tests required, in addition to the production quantity in such case for the next production batch, additional leak before break (LBB) (*see* **9.2.6**) on one cylinder shall be performed.

In the course of the type approval process, the inspector shall select the necessary cylinders for testing and supervise the following tests on the cylinders selected.

9.2.2 The tests specified in **9.3** (Material Tests) on one cylinder, the test pieces being identifiable with the batch.

9.2.3 *Pressure Cycling Test and Hydraulic Bursting Test*

Two finished cylinders after marked, from the first batch made to new design shall be subjected to pressure cycling test. This test shall be carried out with a non-corrosive liquid subjecting the cylinders to successive pressurization at an upper cyclic pressure which is equal to the hydraulic test pressure followed by de-pressurization to lower cyclic test pressure. The cylinder shall withstand 12 000 cycles without failure.

The value of the lower cycling pressure shall not exceed 10 percent of the upper cyclic pressure, but shall have an absolute maximum of 30 kgf/cm^2.

The cylinder shall actually experience the maximum and minimum cyclic pressure during the test.

The frequency of reversals of pressures shall not exceed 0.25 Hz (15 cycles/min). The temperature measured on the outside surface of the cylinder shall not exceed 65°C during the test.

The test shall be considered satisfactory, if the cylinder attains the required number of cycles without developing a leak.

After the test, base of one cylinder shall be sectioned in order to measure the thickness to ensure that the thickness is not less than the minimum prescribed in the approved drawing. Another cylinder shall be subjected to burst test.

9.2.4 The actual burst pressure shall be not less than 45 MPa (450 bar).

9.2.5 The cylinder shall burst without fragmentation.

9.2.6 *Leak Before Break Test* (*LBB*)

One finished cylinder shall be pressure cycled between 2 MPa (20 bar) and 30 MPa (300 bar) at a rate not to exceed 15 cycles/min.

The cylinder shall with stand 12 000 pressure cycles and then the test shall be continued up to either 45 000 pressure cycles or till it fails by leakage. It shall not fail by burst.

9.2.7 *Bonfire Test*

One or two cylinders as appropriate shall be tested in accordance with Annex C and meet the requirements listed therein.

NOTE — This test is for finished cylinder complete with fire protection system that is, cylinder valve, PRV and/or integral thermal insulation.

9.2.8 Changes of design specified in Table 4 shall require only the prototype testing as specified in the table.

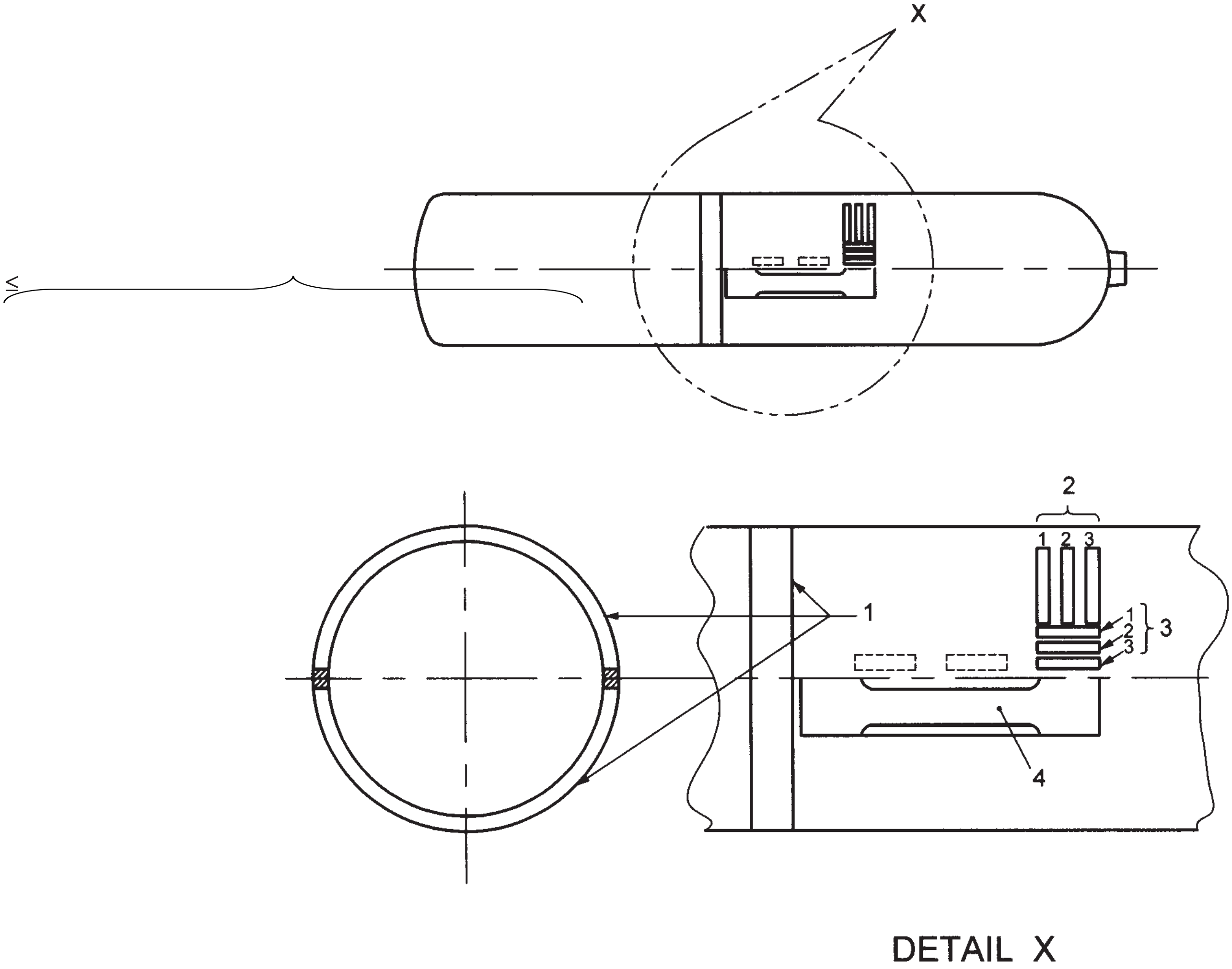
Table 4 Change of Design

(*Clause* 9.2.8)

Sl No.	Design Change	Type of Test Hydraulic Bursting (**9.2.3**)	 Pressure Cyclic at Ambient Temperature (**9.2.3**)	 Leak Before Break (**9.2.6**)	 Bonfire (**9.2.7**)
(1)	(2)	(3)	(4)	(5)	(6)
i)	Diameter change 20 percent	x	x	—	—
ii)	Diameter change > 20 percent	x	x	x	x
iii)	Length change 50 percent	x	—	—	x[1]
iv)	Length change > 50 percent	x	x	—	x[1]
v)	Working pressure change 20 percent[2]	x	x	—	—
vi)	Dome shape	x	x	—	—
vii)	Opening size	x	x	—	—
viii)	Change in manufacturing process	x	x	—	—
ix)	Pressure relief device	—	—	—	x

[1] Test only required when length increases.

[2] Only when thickness change proportional to diameter and/or pressure change.



Key

1 — Bend test pieces

2 — Transverse impact test pieces

3 — Longitudinal impact test pieces (alternative positions shown dotted)

4 — Tensile test piece

Fig. 5 Typical Location of Test Pieces

9.2.9 *Type Approval Certificate*

If the results of the checks are satisfactory, the inspector shall issue a type approval certificate (a typical example is given in Annex D).

9.3 Material Tests

The following tests shall be carried out on heat treated steel cylinders:

a) *Tensile Test* — One in longitudinal direction (*see* **9.3.1**),
b) *Bend Test* — Four in circumferential direction (*see* **9.3.2**),
c) *Impact Test* — Three each in longitudinal or transverse direction (*see* **9.3.3**), and
d) *Sulphide Stress Cracking Resistance Test* (*see* **9.3.4**).

NOTE — For location of test pieces, *see* Fig. 5.

9.3.1 *Tensile Test*

The tensile test specimen shall be made from the strip cut longitudinally from the finished cylinder and shall be carried out in accordance with IS 1608 on a test specimen with a gauge length equal to 5.65 . The two faces of test piece representing the inside and outside surface of the cylinder shall not be machined but shall represent the surface of the container as manufactured. The ends only may be flattened for gripping in the testing machine. The tensile strength, yield strength shall not be less than minimum specified in design and drawing and percentage elongation measured shall not be less than 14 percent. In no case actual maximum tensile strength R_m shall exceed 1 100 MPa.

9.3.2 *Bend Test*

The bend test (*see* Fig. 6) shall be carried out on specimen obtained by cutting a ring into four strips of equal length. The width of the ring shall be 25 mm unless 25 mm is less than four times the minimum agreed finished thickness (including additional allowance, if any) in which case the width shall be not less than four times the agreed finished thickness. Each strip shall be machined only on the edges. The strip shall remain un-cracked when bent inwards around a mandrel of appropriate diameter as given in Table 5 until the interior edges are at a distance apart not greater than the diameter of the mandrel D_F.

9.3.2.1 The maximum diameter of the former (D_F) shall be established from Table 5. For the actual tensile strength (R_m) given in Table 5.

D_F = $n \times t$; where t is wall thickness of cylinder at the position of testing

Table 5 Bend Test Requirements
(*Clause* 9.3.2)

Sl No. (1)	Actual Tensile Strength (MPa) (2)	Bend Test Valve R_m of n (3)
i)	Up to and including 800	4
ii)	Above 800 up to and including 880	5
iii)	Above 880 up to and including 950	6
iv)	Above 950 up to and including 1 100	7

9.3.3 *Impact Test*

Except for the requirements set out below, the test shall be carried out in accordance with IS 1757.

The impact test pieces shall be taken in the direction as required in Table 6 from the wall of the cylinder. The notch shall be perpendicular to the face of the cylinder wall (*see* Fig. 7). For longitudinal tests, the test piece shall be machined all over (on six faces). If the wall thickness does not permit a final test piece width of 10 mm, the width shall be as near as practicable to the nominal thickness of the cylinder wall. The test pieces taken in the transverse direction shall be machined on four faces only, the outer face of the cylinder wall unmachined and the inner face optionally machined as shown in Fig. 8. The test results should be reported in both Joules and Joules/cm².

Table 6 Impact Test Acceptance Values
(*Clauses* 9.3.3 *and* 9.3.3.1)

Sl No. (1)	Cylinder Diameter D_o, in mm (2)		140 (3)			140 (4)
i)	Direction of testing		Transverse			Longitudinal
ii)	Width of the test piece, in mm		3 – 5	5 – 7.5	7. 5 – 10	3 – 10
iii)	Test temperature, in °C[1]		-20			-20
iv)	Impact strength in J/cm², *Min*	Mean of 3 specimens	30	35	40	60
		Individual specimen	24	28	32	48

[1] For applications at lower temperatures the test shall be carried out at the lowest temperature specified.

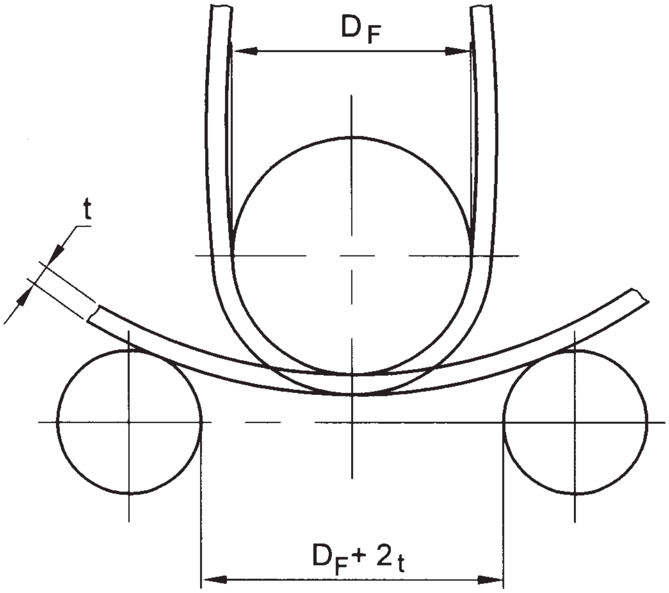


FIG. 6 ILLUSTRATION OF BEND TEST

9.3.3.1 Minimum acceptance values are given in Table 6.

9.3.4 *Sulphide Stress Cracking Resistance Test*

If the upper limit of the specified tensile strength for the steel exceeds 950 MPa, the steel from a finished cylinder shall be subjected to a sulphide stress cracking test in accordance with Annex E and meet the requirements listed therein.

10 BATCH TEST

Each batch of 202 or less cylinders shall be produced from the material of same source and subjected to same heat treatment.

10.1 The following tests shall be carried on each batch of cylinders:

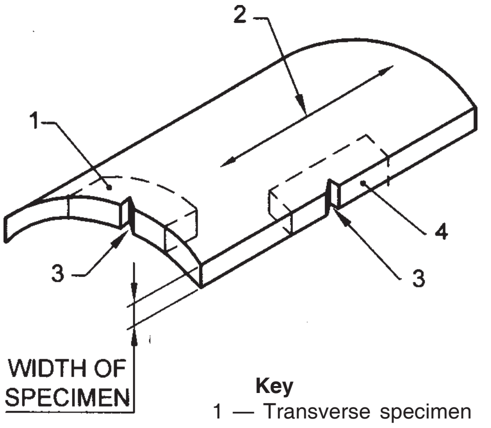
a) Material test on one cylinder that is,

   1) tensile test as per **9.3.1**,
   2) bend test as per **9.3.2**, and
   3) impact test as per **9.3.3**.

b) Pressure cycling and burst test as per **10.2**.

10.2 Pressure Cycling and Burst Test

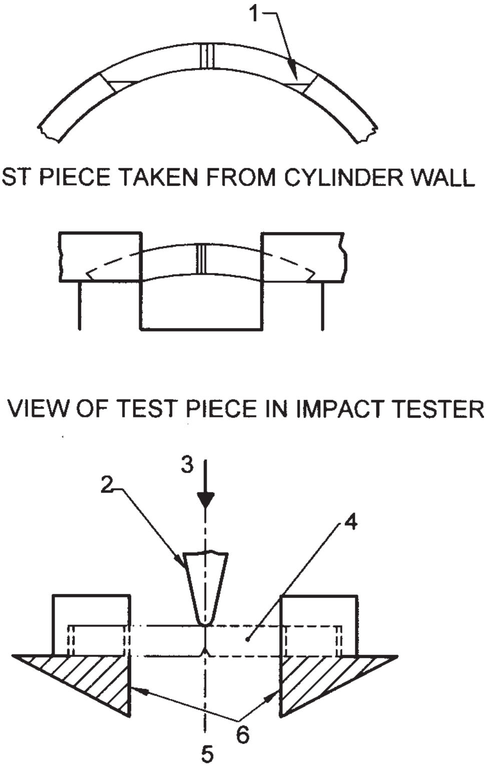
One cylinder shall be drawn at random from a batch of 202 or less heat treated cylinders and shall be subjected to pressure cycling test as given in **9.2.3** at upper cyclic pressure equal to working pressure



Key
1 — Transverse specimen
2 — Cylinder longitudinal - axis
3 — Charpy - V - notch perpendiculer to wall

4 — Longitudinal specimen

FIG. 7 DESCRIPTION OF TRANSVERSE AND LONGITUDINAL IMPACT TEST PIECES



a) TEST PIECE TAKEN FROM CYLINDER WALL

b) FRONT VIEW OF TEST PIECE IN IMPACT TESTER

c) TOP VIEW OF TEST PIECE IN IMPACT TESTER

Key

1 — Machining optional. 2 — Striker. 3 — Direction of strike.
4 — Test piece. 5 — Centre of strike. 6 — Anvils.

FIG. 8 DESCRIPTION OF TRANSVERSE IMPACT TESTING

for 40 000 cycles. The value of lower cyclic pressure shall not exceed 10 percent of upper cyclic pressure, but shall have absolute maximum pressure of 30 kgf/cm^2. The test shall be considered satisfactory, if the cylinder attains the required number of cycles without developing a leak. Subsequently, same cylinder shall be subjected to burst test.

11 TEST ON EVERY CYLINDER

Following tests shall be performed on each cylinder of every batch:

11.1 Hardness Test

Hardness of each cylinder shall be recorded by testing on the parallel wall at the centre. None of the results shall be outside the limits specified on the design drawing.

Hardness testing shall be carried out in accordance with IS 1500 or IS 1586. The indenter and applied load shall be such that it shall not damage the cylinder. The test shall be carried out after final heat treatment.

Test values for hardness at the top, mid-section and base shall be recorded for those processes where cylinders are quenched by vertical immersion into the quench tank. Where the cylinders are immersed horizontally into the quenchant, hardness values shall be recorded at two points around the cylindrical mid-section of the parallel wall.

The hardness values obtained thus shall be in the range specified for the design.

The cylinders which are found to have hardness value beyond the specified range shall be subjected to appropriate re-heat treatment to achieve the hardness values within specified range.

11.2 Hydrostatic Stretch Test

Test shall be carried out in accordance with the method specified in IS 5844. Pressure greater than 80 percent of the test pressure shall not be applied to any cylinder before the test.

The cylinder shall be rejected, if it shows a permanent expansion (that is volumetric expansion after the pressure has been released) in excess of 10 percent of the total volumetric expansion measured at the test pressure P_h.

The total and permanent expansion readings shall be recorded together with the corresponding serial number of each cylinder tested, so that the elastic expansion (that is total expansion less permanent expansion) under the test pressure can be established for each cylinder.

11.3 Ultrasonic Examination

Each cylinder shall be ultrasonically examined for defects in accordance with Annex B. Examination of such cylinders shall be carried out after heat treatment.

11.4 Leakage Test

Cylinders which have been closed at the end by forging or spinning, and which have passed the hydrostatic stretch test shall be subjected to a pneumatic pressure equal to 60 percent of the hydrostatic test pressure, and shall thereupon show no signs of leak.

11.5 Water Capacity

The manufacturer shall check and record the water capacity of each cylinder in order to ensure compliance that the water capacity is within the tolerance of ± 2.5 percent of nominal water capacity.

12 CERTIFICATION

Each batch of gas cylinders conforming to all the requirements of this standard shall be covered by a certificate, signed by the Inspecting Authority's representative. A typical example of a suitably worded certificate is given in Annex F.

Copies of the certificate shall be issued to the manufacturer. The original certificate shall be retained by the manufacturer and the copy by Inspection Body in accordance with the Regulations of the Statutory Authority.

13 CYLINDER MARKING

13.1 Each cylinder shall be permanently stamped with the following:

a) Serial No.;
b) Identification of manufacturer;
c) Month and year of hydrostatic test, such as MM/YYYY (for example 08/2024)
d) Number of this standard;
e) Test pressure, in Bar or kgf/cm^2 at 15°C;
f) The tare weight, in kg, and nominal water capacity, in litres;
g) Inspector's official mark;
h) The design working pressure in Bar / kgf/cm^2 at 15°C;
j) 'ONB-CNG' to show the intended application; and
k) "DO NOT USE AFTER XX/XXXX" where XX/XXXX identifies month and year of expiry.
m) Minimum guaranteed wall thickness of the cylindrical shell, in mm; and
n) Identification of cylinder thread, for example:
   1) T1S1 for Type 1 Size 1 threads mark.
   2) T1S2 for Type 1 Size 2 threads mark.
   3) T1S3 for Type 1 Size 3 threads mark.
   4) T3 for Type 2 threads mark.
   5) T4S1 for Type 4 Size 1 threads mark.
   6) T4S2 for Type 4 Size 2 threads mark.
   7) T4S3 for Type 4 Size 3 threads mark.

NOTES

1 The period between the dispatch date and the expiry date shall not exceed the specified service life. The expiry date may be applied to the cylinder at the time of dispatch, provided that the cylinders have been stored in a dry location without internal pressure,

2 The markings shall be placed in the listed sequence but the specific arrangement may be varied to match the space available. An acceptable example is:

a) Serial number,
b) Manufacturer / Identification number,
c) Month and year of hydrostatic test such as 06/2004,
d) IS Number and ISI Certification Mark,
e) T.P. for example.334 Bar or 340 kgf/cm^2,
f) Tare weight and nominal water capacity in litre,
g) W.P. for example 200 Bar or 204 kgf/cm^2 at 15 °C,
h) ONB-CNG,
j) DO NOT USE AFTER MM/YYYY for example 8/2024.

13.2 The marking shall not be made on the body of the cylinder but shall be at areas in the formed neck where the thickness of metal is greater than the minimum design thickness and where it is adequate for marking to be carried out.

13.2.1 The characters in marking shall normally be at least 6 mm in height. On cylinders below 140 mm diameter, the height may be reduced, but in no case shall the characters be less than 3 mm in height. The indentation shall not be excessive depth.

13.2.2 The stamps used for marking shall have small radius at change of section to avoid the formation of sharp edges in the stamped cylinder.

14 BIS CERTIFICATION MARKING

The cylinder shall be marked with the Standard Mark.

14.1 The use of the Standard Mark is governed by the provisions of the *Bureau Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which a license for the use of the Standard Mark may be granted to the manufacturers or producers may be obtained from the Bureau of Indian Standards.

15 COLOUR IDENTIFICATION

15.1 The cylinder shall be painted externally in accordance with the colour scheme specified in IS 4379 or as specified by statutory authority. The external surface of cylinder shall be painted with following paint system and total dry film thickness of minimum 70 microns shall be maintained:

a) Epoxy Primer (two component system) 1 coat – Zinc Phosphate / Zinc Chromate/Zinc Rich
b) Epoxy / Polyurethane (two component system) 1 coat

15.2 Cylinder manufactured for export shall be painted externally as agreed to between the purchaser and the manufacturer.

16 RECORDS

Records of all the tests made at the cylinder manufacturer's works shall be kept for the life time of the cylinder and copies of test certificates shall be forwarded to the purchaser of the cylinder and the inspecting authority.

17 PREPARATION FOR DESPATCH

Before being despatched from the manufacturer's works, all cylinder shall be thoroughly cleaned and all particles of grit, filings or other matter which may have collected inside the cylinder during the course of manufacture, heat treatment and testing shall be removed completely and the cylinder dried internally. If cylinder is heated for drying the temperature shall not exceed 200°C. Cylinders not immediately closed by fitting of a valve and safety devices if applicable, shall have plugs suitably designed to prevent ingress of moisture and to protect threads, fitted to all the openings. A corrosion inhibitor (for example oil-containing) shall be sprayed into the cylinder prior to despatch. The outside of the cylinder shall be given a suitable protective coating before despatch.

ANNEX A

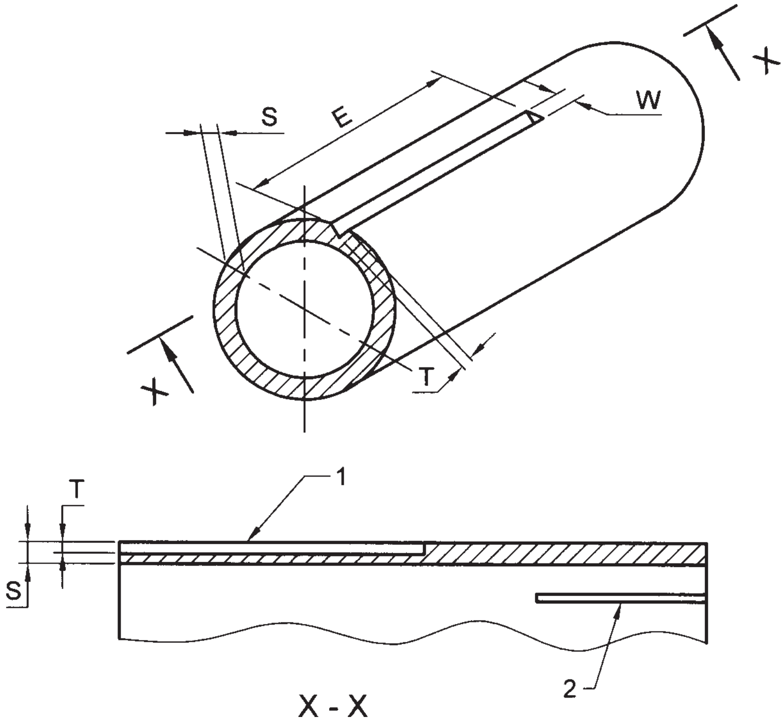
MANUFACTURING DEFECTS

(*Clause* 7.3)

Defect (1)	*Description* (2)	*Conditions for Rejection and/ or Actions* (3)	*Repair/Reject* (4)
Bulge	Visible swelling of the wall	All cylinders with such a defect	Reject
Dent (flats)	A depression in the wall that has neither penetrated nor removed metal (*see* Fig. 9) (*see also* 'excessive grinding or machining' below).	a) When the depth of the dent exceeds 2 percent of the external diameter of the cylinder. b) When the depth of the dent is greater than 1 mm and when the diameter of the dent is less than 30 times its depth. NOTE — On small diameter cylinders these general limits may have to be adjusted. Consideration of appearance also plays a part in the evaluation of dents, especially in the case of small cylinders.	Reject Permit repair

Defect (1)	*Description* (2)	*Conditions for Rejection and/ or Actions* (3)	*Repair/Reject* (4)
Cut, gouge, metallic or scale impression	An impression in the wall where metal has been removed or redistributed (due basically to the introduction of foreign bodies on the mandrel or matrix during extrusion or drawing operations)	a) *Inside defect* : if not superficial with sharp notches more than 5 percent of wall thickness NOTE — Consideration of appearance and localization (in thicker part with lower stresses) can be taken into account.	Reject
		b) *Outside defect* : when the depth exceeds 5 percent of the wall thickness times the thickness of the cylinders.	Repair
Dent containing cut or gouge	A depression in the wall which contains a cut or gouge (*see* Fig.10)	All cylinders with such defects	Reject
Excessive grinding or machining	Local reduction of wall thickness by grinding or machining	a) When the wall thickness is reduced to below the minimum drawing thickness; and	Reject
		b) When it results in the formation of a dent.	*See* 'dent' above
Rib	A longitudinal raised surface with sharp corners (*see* Fig. 11)	*Inside defect* : if height or depth exceeds 5 percent of wall thickness or if the length exceeds 10 percent of the length of the cylinders.	Repair if possible or reject
Groove	A longitudinal notch (*see* Fig. 12)	*Outside defect* : when the height or depth exceeds 5 percent of the wall thickness or when the length exceeds 5 × the thickness of the cylinders	Repair if possible
Crack	Split, material separation	a) When not removable within thickness tolerance; and	Reject
		b) When removable within thickness tolerance	Repair
Neck cracks	Appear as lines, which run vertically down the thread and across the thread faces. (They should not be confused with tap marks or thread machining mark) (*see* Fig. 13)	All cylinders with such defects	Reject
Shoulder folds	Folding with peaks and troughs situated in the internal shoulder area, which can propagate into the threaded area of the shoulder (*see* Fig. 14)	a) Folds or cracks that are visible as a line of oxide running into the threaded portion should be removed by a machining operation until the lines of oxide are no longer visible. After machining, the whole area should be re-inspected carefully and the wall thickness verified.	Repair if possible

Defect (1)	*Description* (2)	*Conditions for Rejection and/ or Actions* (3)	*Repair/Reject* (4)
and/or shoulder cracks	Cracks can start from folds in the internal shoulder area and propagate into the cylindrical machined or threaded area of the shoulder (*see* Fig. 15 shows exactly where shoulder cracks start and how they propagate).	b) If folding or lines of oxide have not been removed by machining, if cracks are still visible or if wall thickness is unsatisfactory; and	Reject
		c) Folds which extend beyond the machined area and are clearly visible as open depressions where no oxides have been trapped in the metal, should be accepted provided that the peaks are smooth and the root of the depression is rounded.	Acceptable
Internal cracks in base	Splits in the metal of the bottom of the cylinder in star form	a) When not removable within thickness tolerance; and	Reject
		b) When removable within thickness tolerance.	Repair
Orange peel surface	Orange peel appearance due to discontinuous metal flow	If sharp cracks are visible in the orange peel surface	Acceptable for non-aggressive gases
Internal neck threads damaged or out of tolerance	Neck threads damaged, with dents, cuts, burrs or out of tolerance	a) When the design permits it, threads may be retapped and re-checked by the appropriate thread gauge and carefully visually re-examined. The appropriate number of effective threads shall be guaranteed; and	Repair
		b) If not repairable.	Reject
Pitting	Severe surface corrosion	All cylinders with such defects visible after shot blasting	Reject
Non-conformity with design drawing	—	All cylinders presenting such a defect	Repair if possible or reject
Neck ring not secure	Neck ring turns under application of low torque, or pulls off under low axial load (*see* **6.7.2**)	All cylinders presenting such a defect	Repair possible according to approved method only
Arc or torch burns	Partial burning of the cylinder metal, the addition of weld metal or the removal of metal by scarfing or cratering	All cylinders presenting such a defect	Reject



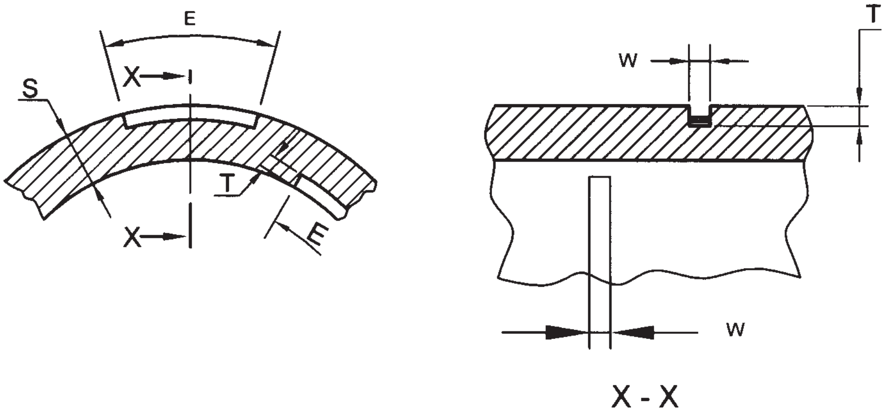
KEY

1 — EXTERNAL REFERENCE NOTCH
2 — INTERNAL REFERENCE NOTCH

NOTE

T (5 0.75) % *S* BUT 0.2 mm *T* 1 mm
W 2T, BUT IF NOT POSSIBLE THEN *W* 1 mm
E 50 mm

FIG. 9 SCHEMATIC REFERENCE NOTCHES FOR LONGITUDINAL DEFECTS



NOTE

T (5 0.75) % *S* BUT 0.2 mm *T* 1 mm
W 2T, BUT IF NOT POSSIBLE THEN *W* 1 mm
E 50 mm

FIG. 10 SCHEMATIC REFERENCE NOTCHES FOR CIRCUMFERENTIAL DEFECTS

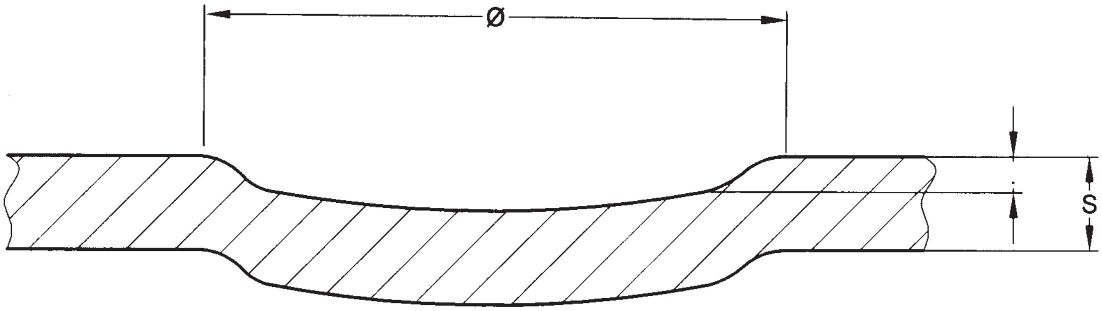


FIG. 11 DENT

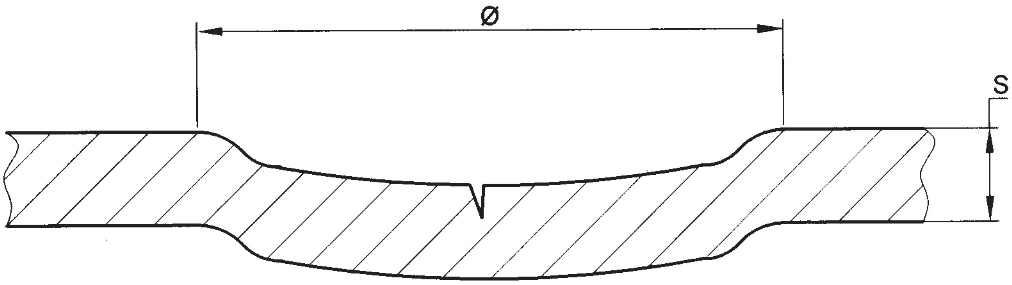


FIG. 12 DENT CONTAINING CUT OR GOUGE

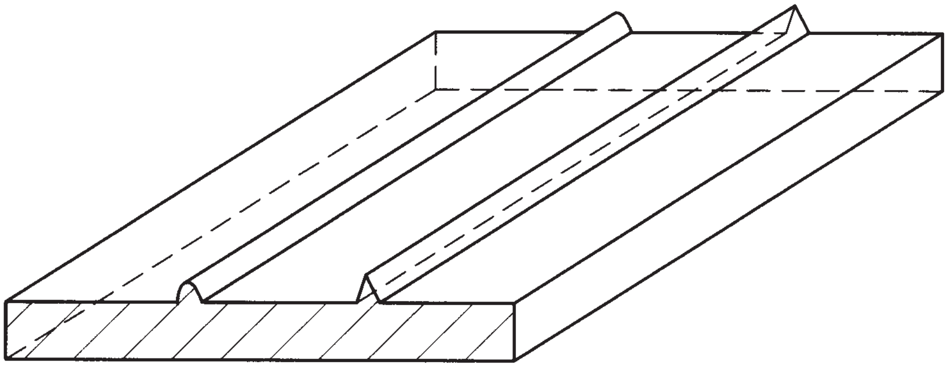


FIG. 13 RIBS

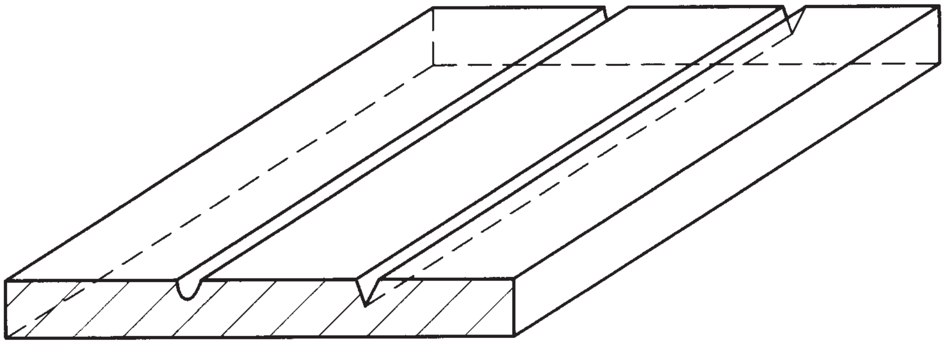
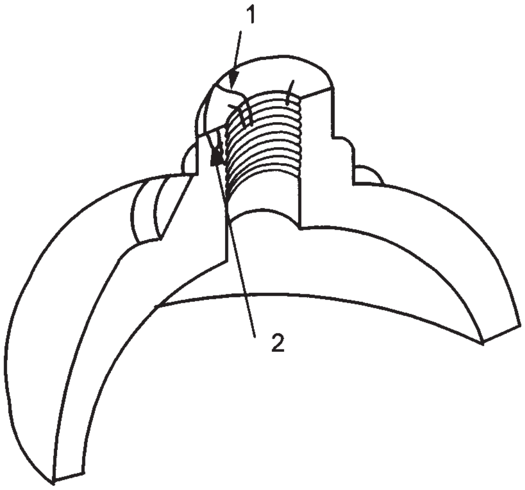


FIG. 14 GROOVES



Key

1 — Neck cracks

2 — Propagated crack in the neck

FIG. 15 NECK CRACKS

ANNEX B

(*Clause* 7.4)

ULTRASONIC DEFECT DETECTION AND THICKNESS MEASUREMENT

B-1 SCOPE

This Annex is based on techniques used by cylinder manufacturers. Other techniques of ultrasonic inspection may be used, provided these have been demonstrated to be suitable for the manufacturing method.

B-2 GENERAL REQUIREMENTS

The ultrasonic testing equipment shall be capable of at least detecting the reference standard as described in **B-3.2**. It shall be serviced regularly in accordance with the manufacturer’s operating instructions to ensure that its accuracy is maintained. Inspection records and approval certificates for the equipment shall be maintained.

The operation of the test equipment shall be by trained personnel and supervised by qualified and experienced personnel certified to level 2 of ISNT/ASNT.

The outer and inner surfaces of any cylinder which is to be tested ultrasonically shall be in a condition suitable for an accurate and reproducible test.

For flaw detection the pulse echo system shall be used. For thickness measurement either the resonance method or the pulse echo system shall be used. Either contact or immersion techniques of testing shall be used.

A coupling method which ensures adequate transmission of ultrasonic energy between the testing probe and the cylinder shall be used.

B-3 FLAW DETECTION OF THE CYLINDRICAL PARTS

B-3.1 Procedure

The cylinders to be inspected and the search unit shall have a rotating motion and translation relative to one another such that a helical scan of the cylinder is described. The velocity of rotation and translation shall be constant within ± 10 percent. The pitch of the helix shall be less than the width covered by the probe (at least a 10 percent overlap shall be guaranteed) and be related to the effective beam width such as to ensure 100 percent coverage at the velocity of rotation and translation used during the calibration procedure.

An alternative scanning method may be used for transverse defect detection, in which the scanning or relative movement of the probes and the work piece is longitudinal, the sweeping motion being such as to ensure a 100 percent surface coverage with about 10 percent overlap of the sweeps.

The cylinder wall shall be tested for longitudinal defects with the ultrasonic energy transmitted in both circumferential directions and for transverse defects in both longitudinal directions.

In this case or when optional testing is carried out on the transition areas between the wall and neck and/or wall and base, this may be conducted manually if not carried out automatically.

The effectiveness of the equipment shall be periodically checked by passing a reference standard through the test procedure. This check shall be carried out at least at the beginning and end of each shift. If during this check the presence of the appropriate reference notch is not detected then all cylinders tested subsequent to the last acceptance check shall be retested after the equipment has been re-set.

B-3.2 Reference Standard

A reference standard of convenient length shall be prepared from a cylinder of similar diameter and wall thickness range, and from material with the same acoustic characteristics (subjected to same heat treatment) and surface finish as the cylinder to be inspected. The reference standard shall be free from discontinuities which may interfere with the detection of the reference notches.

Reference notches, both longitudinal and transverse, shall be machined on the outer and inner surface of the standard. The notches shall be separated such that each notch can be clearly identified.

Dimensions and shape of notches are of crucial importance for the adjustment of the equipment (*see* Fig. 16 and Fig. 17).

The length of the notches (*E*) shall be no greater than 50 mm.

The width (*W*) shall be not greater than twice the nominal depth (*T*). However, where this condition cannot be met a maximum width of 1 mm is acceptable.

The depth of the notches (*T*) shall be 5 percent ± 0.75 percent of the nominal thickness (*S*) with a minimum of 0.2 mm and a maximum of 1 mm, over the full length of the notch. Run-outs at each end are permissible.

The notch shall be sharp edged at its intersection with the surface of the cylinder wall. The cross-section of the notch shall be rectangular except where spark erosion machining methods are used; then it is acknowledged that the bottom of the notch will be rounded.

The shape and dimensions of the notch shall be demonstrated by an appropriate method.

B-3.3 Calibration of Equipment

Using the reference standard described in **B-3.2**, the equipment shall be adjusted to produce clearly identifiable indications from inner and outer reference notches. The amplitude of the indications shall be as near equal as possible. The indication of smallest amplitude shall be used as the rejection level and for setting visual, audible, recording or sorting devices. The equipment shall be calibrated with the reference standard or probe, or both, moving in the same manner, in the same direction and at the same speed as will be used during the inspection of the cylinder. All visual, audible, recording or sorting devices shall operate satisfactorily at the test speed.

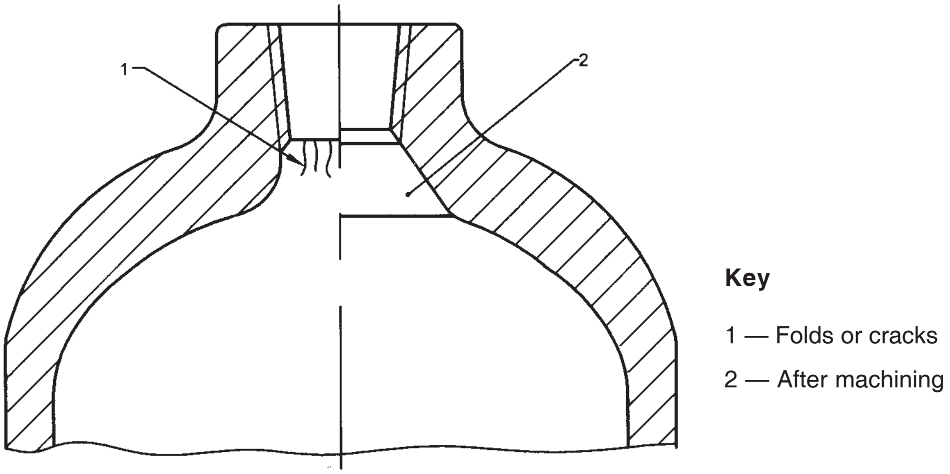
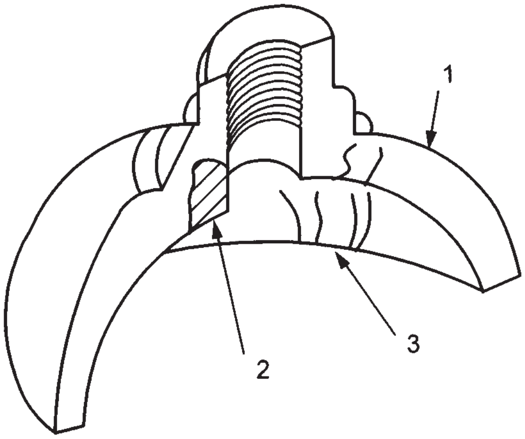


FIG. 16 CYLINDER SHOULDER FOLDS OR CRACKS BEFORE AND AFTER MACHINING



Key

1 — Shoulder cracks

2 — Propagated crack in the shoulder
3 — Folds

FIG. 17 SHOULDER CRACKS

B-4 WALL THICKNESS MEASUREMENT

If the measurement of the wall thickness is not carried out at another stage of production, the cylindrical part shall be 100 percent examined to ensure that the thickness is not less than the guaranteed minimum value.

B-5 INTERPRETATION OF RESULTS

Cylinders with indications which are equal to or greater than the lowest of the indications from the reference notches shall be withdrawn. Surface defects may be removed; after removal the cylinders shall be re-subjected to ultrasonic flaw detection and thickness measurement.

Any cylinder which is shown to be below the guaranteed minimum wall thickness shall be rejected.

B-6 CERTIFICATION

The ultrasonic testing shall be certified by the cylinder manufacturer.

Every cylinder, which has passed the ultrasonic testing in accordance with this standard, shall be stamp-marked with the symbol ‘UT’.

ANNEX C

(*Clause* 9.2.7)

BONFIRE TEST

C-1 GENERAL

The bonfire test is designed to demonstrate that finished cylinders, complete with the fire protection system (cylinder valve, pressure relief devices and/ or integral thermal insulation) specified in the design, will prevent the rupture of the cylinder when tested under the specified fire conditions.

Precautions shall be taken during fire testing in the event that cylinder rupture occurs.

C-2 CYLINDER SET-UP

The cylinder shall be placed horizontally with the cylinder bottom approximately 100 mm above fire source.

Metallic shielding shall be used to prevent direct flame impingement on cylinder valves, fittings, and/ or pressure relief devices. The metallic shielding shall not be in direct contact with the specified fire protection system (pressure relief devices or cylinder valve).

Any failure during the test of a valve, fitting or tubing that is not part of the intended protection system for the design shall in-validate the result.

C-3 FIRE SOURCE

A uniform fire source of 1.65 m length shall provide direct flame impingement on the cylinder surface across its entire diameter.

Any fuel may be used for the fire source provided it supplies uniform heat sufficient to maintain the specified test temperatures until the cylinder is vented. The selection of a fuel should take into consideration air pollution concerns. The arrangement of the fire shall be recorded in sufficient detail to ensure that the rate of heat input to the cylinder is reproducible.

Any failure or inconsistency of the fire source during a test shall invalidate the result.

C-4 TEMPERATURE AND PRESSURE MEASUREMENTS

Surface temperatures shall be monitored by at least three thermocouples located along the bottom of the cylinder and spaced not more than 0.75 m apart.

Metallic shielding shall be used to prevent direct flame impingement on the thermocouples. Alternatively, thermocouples may be inserted into blocks of metal measuring less than 25 mm^2.

Thermocouple temperatures and the cylinder pressure shall be recorded at intervals of every 30 s or less during the test.

C-5 The cylinder shall be pressurized to working pressure with natural gas or compressed air and tested in the horizontal position at working pressure and at 25 percent of working pressure if a thermally activated pressure relief devices (PRD) is not used.

Immediately following ignition, the fire shall produce flame impingement on the surface of the cylinder along the 1.65 m length of the fire source and across the cylinder diameter.

Within 5 min of ignition the temperature at least one thermocouple shall indicate a temperature > 590 °C. This minimum temperature shall be maintained for the remainder of the test.

For cylinders of length 1.65 m or less, the centre of the cylinder shall be positioned over the centre of the fire source.

For cylinders of length greater than 1.65 m, the cylinder shall be positioned as follows:

a) If the cylinder is fitted with a pressure relief device at one end the fire source shall commence at the opposite end of the cylinder;
b) If the cylinder is fitted with pressure relief devices at both ends, or at more than location along the length of the cylinder, the centre of the fire source shall be centred midway between the pressure relief devices that are separated by the greatest horizontal distance; and
c) If the cylinder is additionally protected using thermal insulation, then two fire tests at service pressure shall be performed, one with the fire centred midway along the cylinder length, and the other with the fire commencing at one of the ends of a second cylinder.

C-6 ACCEPTANCE RESULTS

The cylinder shall vent through the pressure relief device.

ANNEX D

(*Clause* 9.2.9)

TYPE APPROVAL CERTIFICATE

This Annex provides an example of a suitable form of a type approval certificate. Other formats also acceptable.

Issued by……………………………………………………………………………………………………….

(Authorized Inspection Authority)

………

Applying IS Standard ……………………………………………………………...……………………………

concerning

SEAMLESS STEEL GAS CYLINDER

………

Approval No………………...………………

Type of Cylinder………………………………………………………..…………………………………………

(Description of the family of cylinders (Drawing No.) which has received type approval)

P_h ………………………bar, D_{min} ………………………mm, D_{max} ………………………mm, a'………...………..mm

Shape of base: b……....…………………mm

L_{min} ………………………mm, L_{max} ………………………mm, V_{min} ………………………litre, V_{max} ………...………..litre

Material and heat treatment:

Material and characteristics: Material R_e……………………………MPa, R_g ………………………..MPa

Manufacturer or agent:

(Name and address of manufacturer or its agent) All information may be obtained from

(Name and address of approving body)

Date:

Place:

(Signature of Inspector)

ANNEX E

(*Clause* 9.3.4)

SULPHIDE STRESS CRACKING TEST FOR STEEL

E-1 Tests shall be conducted on a minimum of three tensile specimens with a gauge diameter of 3.81 mm machined from the wall of a finished cylinder. The specimens shall be placed under a constant tensile load equal to 60 percent of the specified minimum yield strength of the steel, immersed in a solution of distilled water buffered with 0.5 percent (mass fraction) sodium acetate trihydrate and adjusted to an initial *p*H of 4.0 using acetic acid. The solution shall be continuously saturated at room temperature and pressure with 0.414 kPa hydrogen sulphide (balance nitrogen). The tested specimens shall not fail within test duration of 144 h. Specimen that fails outside gauge are considered as invalid test.

NOTES

1 This is a test for type of material, duly heat treated, and results can be used for any cylinders from that material, with same heat treatment.

2 For guidance Method A — NACE standard tensile test procedure, as described in NACE standard TM0177-96 may be referred.

ANNEX F

(*Clause* 12)

ACCEPTANCE CERTIFICATE

This Annex provides an example of a suitable from of acceptance certificate. Other formats are also acceptable.

Acceptance certificate for seamless steel cylinders No…………………

A consignment of ……… cylinders consisting of ………. test batches have been inspected and tested ……. according to IS 15490.

Designation or type of gas	*Sl No. of Cylinders*	*Qty.*

Manufacturer’s Nos. : …………………………... to …………………..…………………………......

Owner’s Nos.[1] : …………………………………... to …………………..………………………….......

Manufacturer : ……………………………............ Manufacturer order No.:…………..……........

Address : …………………………………………………………….............…………………..…………….........

Country : ………………………………………....... Date : ………………………...…………….......

Owner/Customer [2] : …………………………….. Purchase Order No. : …….…………………...

Address : …………………………………………………………….............…………………..…………….........

Country : ………………………………………....... Date : ……………………………………….........

TECHNICAL DATA

Water capacity, V : Nominal [1] ………........... litre Nominal length : …………………. mm

Minimum[1] …………...... litre (without cap and without valve)

Test pressure, P_h : ……………………...……bar Outside diameter, D_o : …………... mm

Working pressure [1] at 15 °C, P_w : ………… bar Minimum wall thickness, a : …….. mm

Maximum filling charge [1] : …………………....... kg Drawing No. : …………………………….

Material :

Specified analysis [3] :	C	S	Mn	P	S	Cr	Mo	Ni
Percent, *Max* :								
Percent, *Min* :								

Heat treatment :

Stamp-markings [3] :

……………………………………. ……………………………….

Date Manufacturer

ACCEPTANCE TESTS

1. Measurement taken on one representative cylinder of the batch [4]

Test No. or Batch No. or Cylinder No.	*Covering Serial No……..........to…..……..…*	*Water Capacity,* litre	*Mass Empty,* kg	*Minimum Measured Thickness* mm	
				Wall	Base

2. Mechanical Tests[4]

Test No.	*Cast No.*	*Tensile Test*			*Hardness* HB	*Impact Test*		*Bend Test*
		Yield Stress (R_{ea}) MPa	Tensile Strength (R_m) MPa	Elongation (A) %		Charpy (V) ……. Direction		180° Without Cracking
Minimum Values						Average J/cm^2	Minimum J/cm^2	

This is to certify that the cylinders covered by this Acceptance Certificate have passed the hydraulic pressure test and all the other tests as required in **11** of IS 15490 and they are in accordance with this standard.

Special remarks :

………

………

On behalf of :

………

……………………………………

Date :

……………………………………

(Signature of Inspector)

---

[1] Delete as applicable.
[2] If required by customer.
[3] To be quoted or drawing to be attached.
[4] Need not be filled in if test reports are attached.

ANNEX G

(*Foreword*)

COMMITTEE COMPOSITION

Gas Cylinders Sectional Committee, MED 16

Organization	*Representative(s)*
Petroleum and Explosive Safety Organization, Nagpur	Dr Sudarshan Kamal (***Chairman***) Shri Ashendra Singh (*Alternate*)
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Research & Development Estt (Engineers), Pune	Shri P. K. Chattopadhyay Shri A. Basu (*Alternate*)

Organization	*Representative(s)*
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Member Secretary

SHRI CHANDAN GUPTA
Scientist ‘B’ (MED), BIS

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Tekno Valves, Kolkata	Shri Y. K. Behani Shri R. Behani (*Alternate*)
The Automotive Research Association of India, Pune	Dr S. S. Thipse Shri M. K. Choudhari (*Alternate*)

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Amendment No.	Date of Issue	Text Affected

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AMENDMENT NO. 1 JUNE 2021

TO

IS 15490 : 2017 SEAMLESS STEEL CYLINDERS FOR ON-BOARD STORAGE OF COMPRESSED NATURAL GAS AS A FUEL FOR AUTOMOTIVE VEHICLES — SPECIFICATION

(First Revision)

(*Second cover page*, *foreword*, *para* 2, *last sentence*) — Substitute the following for the existing :

'However, considering the prevailing practices of cylinder manufacturing in the country, changes have been made wherever necessary.'

(*Second cover page*, *foreword*, *para* 4, *last sentence*) — Delete.

(*Second cover page*, *foreword*, *para* 4) — Insert the following new para after para 4:

'Normalized seamless steel cylinders are covered in IS 7285 (Part 1) : 2018 Refillable seamless steel gas cylinders — Specification : Part 1 Normalized steel cylinders. Quenched and tempered steel cylinders are covered in IS 7285 (Part 2) : 2017 Refillable seamless steel gas cylinders — Specification : Part 2 Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa (112 kgf/mm^2)'.

(*Second cover page*, *foreword*, *para* 5, *line* 1) — Substitute 'IS 8451 : 2018 Periodic inspection and testing of seamless steel gas cylinders — Code of practice' *for* 'IS 8541 : 2009 Periodic inspection and testing of high pressure gas cylinders – Code of practice'.

(*Page* 1, *clause* **2**) — Insert the following at the end:

IS No.	*Title*
15958 : 2012	Compressed natural gas (CNG) for automotive purposes — Specification

(*Page* 2, *clause* **3.2.3.1**) — Substitute the following for the existing:

'**3.2.3.1** *General* — Methanol and/or glycol shall not be deliberately added to the natural gas. Cylinders shall be designed suitable for filling with natural gas conforming to IS 15958.'

(*Page* 2, *clause* **3.6**) — Substitute the following for the existing:

'**3.6 Tempering** — Toughening heat treatment which follows quenching, in which the cylinder is heated to a uniform temperature below the lower critical point, AC_1, of the steel.'

(*Page* 2, *clause* **3.7**, *title*) — Substitute 'Yield Strength (R_{eg})' *for* 'Yield Stress (R_e)' and wherever it appears in the standard.

(*Page* 2, *clause* **3.8**) — Substitute the following for the existing:

'**3.8 Batch** — A quantity of up to 200 cylinders plus cylinders for destructive testing of the same nominal diameter, thickness and design, made successively from the same heat number of steel and subjected to the same heat treatment for the same duration of time.'

(*Page* 3, *clause* **4**, *symbol* r) — Insert the following symbol below '*r*':

'R_{ea} = actual value of the yield strength, in MPa, as determined by the tensile test;'

(*Page* 3, *clause* **4**, *symbol* R_g) — Substitute 'R_{mg}' *for* 'R_g' and wherever it appears in the standard.

(*Page* 3, *clause* **4**, *symbol* R_m) — Substitute 'R_{ma}' *for* 'R_m' and wherever it appears in the standard.

(*Page* 3, *Table* 1) — Substitute the following for the existing:

Table 1 Chemical Composition Tolerances

(*Clauses* 5.2.1 *and* 5.3)

Sl No. (1)	Element (2)	Maximum Content (Mass Fraction) Percent (3)	Maximum Permissible Deviations (Mass Fraction) Percent (4)	Maximum Permissible Range (Mass Fraction) Percent (5)
i)	Carbon	< 0.30	0.06	0.06
		≥ 0.30	0.07	0.07
ii)	Manganese	All values	0.30	0.30
iii)	Silicon	All values	0.30	0.30
iv)	Chromium	< 1.50	0.30	0.30
		≥ 1.50	0.50	0.50
v)	Nickel	All values	0.40	0.40
vi)	Molybdenum	All values	0.15	0.15

(*Page* 4, *Table* 2) — Substitute the following for the existing:

Table 2 Maximum Sulphur and Phosphorus Limits (mass fraction) in Percentage

(*Clause* 5.2.2)

Sl. No. (1)	Element (2)	Maximum Content Limits (Mass Fraction) Percent (3)
i)	Sulphur	0.010
ii)	Phosphorus	0.020
iii)	Sulphur + Phosphorus	0.025

(*Page* 4, *Table* 3) — Substitute the following for the existing:

Table 3 Internationally Recognized Steel Compositions (Cast Analyses) (Mass Fraction)

(*Clause* 5.4)

Sl No.	**Element**	**Steel Grade and Conditions (Mass Fraction)** (Percent)	
		for Cr Mo (Q and T)	for C Mn (Q and T)
(1)	(2)	(3)	(4)
i)	Carbon	0.250 - 0.380	0.380, *Max*
ii)	Silicon	0.100 - 0.400	0.100 - 0.350
iii)	Manganese	0.400 - 1.000	1.350 - 1.700
iv)	Phosphorus	0.020, *Max*	0.020, *Max*
v)	Sulphur	0.010, *Max*	0.010, *Max*
vi)	Chromium	0.800 - 1.200	—
vii)	Molybdenum	0.150 - 0.400	—

(*Page* 4, *clause* **5.5**) — Substitute the following for the existing:

'**5.5** Suitable steels other than above may be used with the prior permission of the statutory authority. In such a case, the yield strength and tensile strength of the steel taken for the purpose of calculating the wall thickness of the cylinder shall not be greater than the minimum values specified by the steel manufacturer.'

(*Page* 4, *clause* **6.1.1**) — Substitute the following for the existing:

'**6.1.1** The calculation of the wall thickness of the pressure containing parts shall be related to the guaranteed minimum yield strength (R_{eg}) of the material in the finished cylinder.'

(*Page* 4, *clause* **6.1.2**) — Substitute the following for the existing:

'**6.1.2** For calculation purposes, the value of R_{eg} shall not exceed 0.90 R_{mg}.'

(*Page* 4, *clause* **6.1.3**) — Insert the following sentence at the end:

'P_h is hydrostatic test pressure above atmospheric (1.5 times the working pressure).'

(*Page* 4, *clause* **6.1.3**) — Insert the following new clause:

‘**6.1.4** Cylinders may be designed with one or two openings along the central cylinder axis only.’

(*Page* 4, *clause* **6.2.1**) — Substitute the following for the existing:

‘**6.2.1** *Calculation of Cylindrical Shell Thickness*

6.2.1.1 The guaranteed minimum wall thickness of the cylindrical shell of the cylinder to be calculated using Equations (1) and (2), and additionally condition (3) shall be satisfied.

$$a = \frac{D_\mathrm{o}}{2} \times \left(1 - \sqrt{\frac{10F \times R_\mathrm{eg} - \sqrt{3}P_\mathrm{h}}{10F \times R_{eg}}}\right) \qquad \ldots (1)$$

where the value of F is the lesser of 0.65 / ($R_\mathrm{eg}/R_\mathrm{mg}$) or 0.85 and F is design stress factor (variable)

$R_\mathrm{eg}/R_\mathrm{mg}$ shall not exceed 0.90.

The wall thickness shall also satisfy equation (2)

$$a \geq D_\mathrm{o} / 250 + 1 \qquad \ldots (2)$$

with an absolute minimum of a = 1.5 mm

The burst ratio shall be satisfied by test as given in equation (3)

$$P_\mathrm{b} / P_\mathrm{h} \geq 1.6 \qquad \ldots (3)$$

NOTES

1 It is generally assumed that P_h = 1.5 times working pressure for compressed gases for cylinders designed and manufactured to conform to this standard.

2 R_eg and R_mg shall be in MPa, Diameter in mm and P_h in bar.’

(*Page* 5, *clause* **6.2.2**) — Delete.

(*Page* 5, *clause* **6.3.1**) — Substitute the following for the existing:

‘The thickness, b, at the center of a convex end shall be not less than that required by the following criteria:

$b \geq 1.5\acute{a}$ for $H/D_\mathrm{o} \geq 0.25$

$b \geq 2a'$ *for* $0.25 > H/D_\mathrm{o} \geq 0.2$

where the inside knuckle radius, r, is not less than 0.075 D_o.

NOTE — $H/D_o < 0.20$ is not recommended.’

(*Page* 5, *clause* **6.3.1.1**) — S ubstitute the following for the existing:

‘**6.3.1.1** For cylinders manufactured from plate, the thickness, b, at the centre of a convex end shall be not less than that required by the following criteria:

$$b \geq 1.5\acute{a}\ for\ 0.40 > H / D_o \geq 0.20$$

$$b \geq \acute{a}\ for\ H / D_o \geq 0.40$$

where the inside knuckle radius, r is not less than 0.075 D_o.

NOTE — $H/D_o < 0.20$ is not recommended.’

(*Page* 5, *clause* **6.3.2**) — Delete.

(*Page* 5, *clause* **6.4**) — Delete.

(*Page* 5, *clause* **6.4.1**) — Substitute the following for the existing:

‘**6.4.1** The cylinder manufacturer shall in any case prove by pressure cycling test as given in **9.2.3** that the design is satisfactory.’

(*Page* 7, *Fig.* 2) — Delete.

(*Page* 8, *Fig.* 3) — Delete.

[*Page* 9*, clause* **9.1** j)] — Substitute the following for the existing:

‘j) guaranteed minimum yield strength (R_{eg}) and/or the guaranteed minimum tensile strength (R_{mg}) for the finished cylinder have changed; or’

(*Page* 10*, clause* **9.2.3**, *para* 2) — Substitute the following for the existing:

‘The value of the lower cycling pressure shall not exceed 10 percent of the upper cyclic pressure, but shall have an absolute maximum of 30 bar.’

(*Page* 10, *clause* **9.2.4**) — Substitute the following for the existing:

‘**9.2.4** The actual burst pressure shall be not less than 48 MPa (480 bar).’

(*Page* 11, *Table* 4) — Substitute the following for the existing:

Table 4 Change of Design

(*Clause* 9.2.8)

Sl No.	**Design Change**	**Type of Test**			
		Hydraulic Bursting (*see* **9.2.3**)	Pressure Cyclic at ambient Temperature (*see* **9.2.3**)	Leak Before Break (*see* **9.2.6**)	Bonfire (*see* **9.2.7**)
(1)	(2)	(3)	(4)	(5)	(6)
i)	Diameter change ≤ 20 percent	x	x	—	—
ii)	Diameter change > 20 percent	x	x	x	x
iii)	Length change ≤ 50 percent	x	—	—	x[1]
iv)	Length change > 50 percent	x	x	—	x[1]
v)	Working pressure change ≤ 20 percent[2]	x	x	—	—
vi)	Dome shape	x	x	—	—
vii)	Opening size	x	x	—	—
viii)	Change in manufacturing process	x	x	—	—
ix)	Pressure relief device	—	—	—	x

[1] Test only required when length increases.

[2] Only when thickness change proportional to diameter and / or pressure change.

(*Page* 12, *clause* **9.3.1**, *fourth sentence*) — Substitute the following for the existing:

'The tensile strength, yield strength shall not be less than minimum specified in design drawing and percentage elongation measured shall not be less than 14 percent.'

(*Page* 12, *Table* 5) — Substitute the following for the existing:

Table 5 Bend Test Requirements

(*Clause* 9.3.2)

Sl No.	Actual Tensile Strength, R_m (in MPa)	Value of n
(1)	(2)	(3)
i)	Upto and including 800	4
ii)	Above 800 upto and including 880	5
iii)	Above 880 upto and including 950	6
iv)	Above 950 upto and less than 1 100	7

(*Page* 12, *Table* 6) — Substitute the following for the existing:

Table 6 Impact Test Acceptance Values

(*Clauses* 9.3.3 *and* 9.3.3.1)

Sl. No.	Cylinder Diameter D_o, in mm		> 140			≤ 140
(1)	(2)		(3)			(4)
i)	Direction of testing		Transverse			Longitudinal
ii)	Width of the test piece		3 - 5	> 5 - 7.5	>7.5 - 10	3 - 10
iii)	Test temperature, in °C[1)]		-20			-20
iv)	Impact strength[2)] in J/cm^2, *Min*	Mean of 3 specimens	30	35	40	60
		Individual specimen	24	28	32	48

[1)] For applications at lower temperatures the test shall be carried out at the lowest temperature specified.

[2)] The impact value J/cm^2 is calculated by dividing the impact energy (J) by the actual cross-sectional area below the notch (cm^2) of the Charpy test specimen.

(*Page* 15, *clause* **11.4**) — Substitute the following for the existing:

‘11.4 Leakage Test

Cylinders which have been closed at the end by forging or spinning, and which have passed the hydrostatic stretch test shall be subjected to a pneumatic pressure not less than two third of the hydrostatic test pressure, and shall thereupon show no signs of leak.’

(*Page* 16, *clause* **15**) — Substitute the following for the existing:

‘15 Colour Identification

15.1 The cylinder shall be painted or powder coated externally in accordance with the colour scheme specified in IS 4379 or as specified by statutory authority.

15.2 The external surface of cylinder shall be painted or powder coated.

15.2.1 For painting use the following paint system and total minimum dry film thickness of 70µ shall be maintained:

a) Epoxy Primer (two component system) 1 coat — Zinc Phosphate / Zinc Chromate / Zinc Rich; and

b) Epoxy / Polyurethane (two component system) 1 coat

15.2.2 For powder coating use the coating system with final coat of powder and final minimum coating thickness of 70µ.

15.3 Cylinder manufactured for export shall be painted or powder coated externally as agreed to between the purchaser and the manufacturer.’

(MED 16)

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